Revue suisse de Zoologie 110 (3): 661-668; septembre 2003

Distribution of badger setts and latrines in an intensively cultivated landscape

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Distribution of badger setts and latrines in an intensively cultivated landscape. - We made a survey of badger *Meles meles* setts and latrines in a Swiss agricultural area where food resources are over-abundant and suitable den sites potentially rare. Indeed, badger main sett density was the lower ever recorded (0.07/km^2). Setts were located in small remaining woodlands or in the forested slopes surrounding the cultivated area. We discovered 67 latrines, which could be differentiated into two categories: 1) major latrines used for more than 4 months, 2) minor latrines used for only 1 to 4 months. Major latrines, which are generally considered as territorial marks, were located closer to the main setts than the minor ones. This distribution suggests that badger territorial boundaries are not well defined in this cultivated area.

Key-words: Badger - *Meles meles* - main setts - latrines - territoriality - intensive agriculture.

INTRODUCTION

The European badger (*Meles meles* L., 1758) is bound to a great extent to underground burrows dug most of the time by itself. Several setts are usually distributed throughout the territory of one badger clan. They can be classified into two main categories: the main sett and the outliers. Usually characterised by many entrances, the main setts are permanently occupied by badgers and used for reproduction. There is one main sett for every single social group. Outliers are categorised into annex setts and subsidiaries or peripheral setts (Thornton, 1988; Roper, 1992; Lüps & Wandeler, 1993 *inter alies*). Located up to a few hundred meters away from the main sett and connected to it by a well delimited path, the former have fewer entrances than the main sett and are often occupied intermittently by badgers. On the other hand, the subsidiaries can be situated far away from the main sett and are not connected to it by any path. They are rarely used, mostly as resting sites during foraging periods, or as refuges in case of a sudden threat (Butler & Roper, 1994, 1996). A suitable den site should provide a soil which is easy to dig and well drained, a slope to facilitate the evacuation of the excavated material, and vegetal cover to hide the activities close to the sett and to

Manuscript accepted 10.04.2003

sustain the galleries thanks to the roots (Dunwell & Killingley, 1969; Anrys & Libois, 1983; Skinner *et al.*, 1991; O'Corry-Crowe *et al.*, 1993).

Badgers mark their territorial boundaries with their faeces, which are usually deposited in open pits agglomerated in latrines (Kruuk, 1978; Neal, 1986; Roper *et al.*, 1986; Pigozzi, 1989; Roper *et al.*, 1993). Latrines are most of the time situated close to marked landscape limits such as hedgerows, forest edges, roads or streams (Roper *et al.*, 1986; Harris *et al.*, 1994; Martin *et al.*, 1995). There are also latrines spread within the territory but these are usually smaller and used only over a short period (Roper *et al.*, 1993). Roper *et al.* (1986) and O'Corry-Crowe *et al.* (1993) differentiate 2 types of latrines. The «real» latrines or major latrines encompass many pits and are used regularly year-round. «Temporary Defecation Sites» (=TDS) or minor latrines encompass only a few pits, generally 1 or 2, and are used only over a short period. Major latrines are mostly located close to territorial boundaries whereas TDS are often distributed inside the territory and less bound to landscape limits.

Badgers must face two main limiting factors: food availability and the presence of suitable den sites. In modern agricultural landscapes food resources appear to be quite abundant (Stocker & Lüps, 1984; Seiler *et al.*, 1995). On the other hand, most natural structures tend to disappear, slopes are levelled and cover is rare. Thus, favourable sites for the excavation of suitable dens by badgers seem to be limited. Consequently, we tried to determine how badgers could cope with the apparent scarcity of suitable sites for denning in an intensively cultivated area. Further, we investigated to what extent the cultivated fields were encompassed in badger home ranges using the distribution of latrines as these are thought to be territorial marks.

STUDY AREA AND METHODS

The study was carried out in the Val-de-Ruz (41 km^2; Fig. 1), a cultivated valley of the Swiss Jura Mountains, western Switzerland. Altitude ranges from 650 to 800 m. Surrounded by steep wooded slopes, this valley is potentially suitable for intensive agricultural exploitation on over 80% of its surface (Bouzelboudjen *et al.*, 1993). There are only a few small woods remaining within the cultivated area. They, together with some marginal forest patches, account for a surface of 1.8 km^2 representing only 4.4 % of the area.

Badger setts and latrines were searched for systematically in all forests, forest edges, hedgerows and small woods of the cultivated area. Additionally, we also looked for latrines along roads, streams, fences and break of slopes. The utilisation of setts and latrines was then monitored twice every month from June 1994 to May 1995. Each sett was checked for evidences of occupation by badgers (i.e. footprints, hairs at the entrances, traces of scrubbing or faeces), and classified as described in the introduction into main, annex or subsidiary sett. For every latrine we noted the number of pits and, if present, the number of scats.

Despite the absence of dens in the eastern half of the valley we observed regularly badger tracks and individuals. Thus, we decided in mid-winter 1995 to search for burrows in the forests situated on the slopes surrounding the cultivated area, up to altitudes of between 800 and 1000 m depending on the altitude of the bottom of the valley.

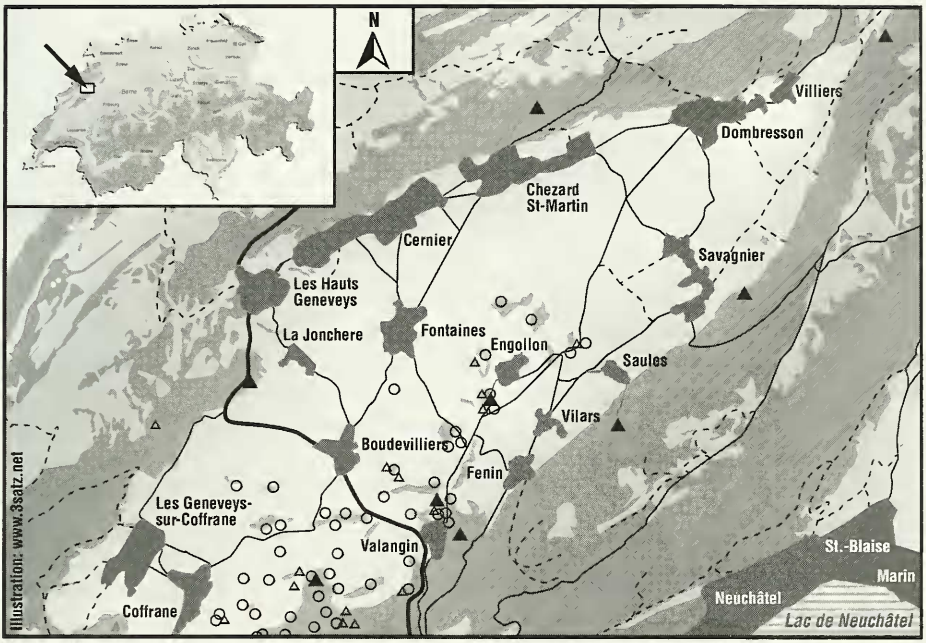

FIG. 1

Distribution of badger setts and latrines in the study area. In black: villages; in grey: woods and forest; in light grey and white (study area): cultivated areas and pastures; black lines: roads; full triangles: main setts; open triangles: outliers; circles: latrines.

The Mann-Whithney U-test was used to test for potential significant differences between main setts and outliers, minor and major latrines, and the distance between latrine type and main sett. Further, we applied a chi square test to determine if the spatial distribution of main setts was different from random.

RESULTS

During the survey, 14 setts, used by badgers, were found within the cultivated area, of which 3 were main ones, 2 annex setts and 9 subsidiaries (proportion main sett to total number of setts: 1:4.1). All setts were located in woodlands (Fig. 1), and 11 of them (78%; all main and annex setts and 6 subsidiaries), were dug in fluvioglacial layers, a highly permeable soil. It has to be noted that only one main sett was situated in a small forest island amid the cultivated area. All others were located in the forests surrounding the valley. Main sett density was 0.07 sett per km^2. The number of entrances was higher in the main setts ($x = 13.7$, $SD = \pm 6.7$) than in the outliers ($x = 2.8$, $SD = \pm 2.9$; Mann-Whithney U-test: $U = 2.471$, $p = 0.0135$). Spatial distribution was statistically different from random ($Chi^2 = 20.48$, $p < 0.001$).

Six additional main setts and 3 outliers were found in the forested slopes surrounding the cultivated area during the second prospecting in winter (Fig. 1). The small number of outliers is due to the fact that this second search was mainly based on previous knowledge of gamekeepers and not on systematical searching.

As all dens were distributed in the western half of the cultivated valley, the search for latrines was concentrated in this area. None of the 67 latrines we discovered were situated in open fields. Most of them were located at forest edges (45%) or hedgerows (42%), and when situated in woodlands, they were close to streams, paths or break of slopes (Fig. 1).

In our study area 2 types of latrines were recorded. On the one hand, latrines used less than 4 months (41/67 latrines) averaged 6.7 (± 6.7) pits. On the other hand, latrines used more than 4 months averaged 19.1 (± 12.7) pits. The number of pits significantly differed between both groups of latrines (Mann-Whithney U-test: U = 25, p = 0.0076). Latrines from the latter group, major latrines, were located closer to the main setts (347 m ± 284) than the minor ones (708 m ± 277; Mann-Whithney U-test: U = -3.358, p = 0.0008). None of the latrines was used for a period longer than 9 months (Fig. 2), and the number of latrines used each month was positively correlated to the number of faeces present (Spearman: N = 12, Rho = 0.816, p = 0.0068)

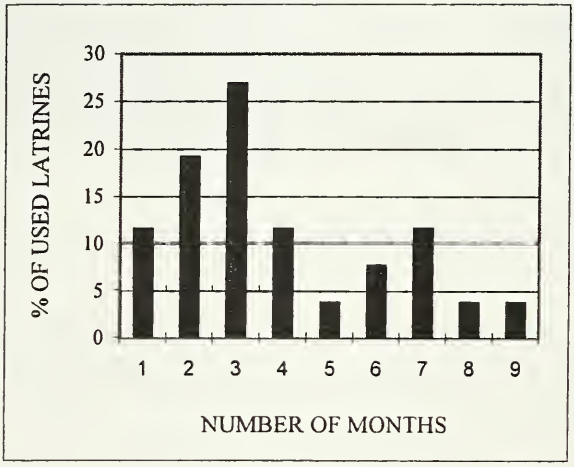

FIG. 2
Proportions of latrines used for a given number of months

DISCUSSION

Main sett density is related to the density of badger clans, as a clan possesses only one main sett (Kruuk, 1978; Neal, 1986). In the Val-de-Ruz, main sett density is 0.07/km^2. This is amongst the smallest density ever observed (Table 1). Apparently, this intensively cultivated area is not a habitat providing suitable den sites. Besides, most main setts of badger clans which home range encompasses the cultivated area, are situated in the forests surrounding the valley. There are only a few setts located in some of the remaining woody islands. In addition, to be suitable, the latter have to provide a slope and a favourable soil. These conditions are absent from the woodlands of the eastern part of the Val-de-Ruz.

TABLE 1. Comparison of main sett densities amongst various studies (bold: results of the present study).

Author(s)	Country	Surface of the study area (km^2)	Number of main setts	Main sett density (km^2)
Butler & Roper, 1996	England	7.75	19	2.45
Cheeseman *et al.*, 1988	England	9	34	3.78
Roper *et al.*, 1986	England	1.3	6	4.61
Roper *et al.*, 1993	England	6.2	15	2.42
Skinner *et al.*, 1991	England	3942	700	0.18
Wilson, 1993	England	1.9	4	2.1
O'Corry-Crowe *et al.*, 1993	Ireland	16	11	0.69
Biancardi & Rinetti, 1999	Italy	180	21	0.12
Marassi & Biancardi, 2002	Italy	58	4	0.07
Pigozzi & Consolati, 1991	Italy	17.5	9	0.50
Kruuk & Parish, 1987	Scotland	12	7	0.58
Do Linh San, 1997	Switzerland	16	6	0.37
Do Linh San, 2002	Switzerland	74	22	0.30
Ferrari, 1997	Switzerland	26	5	0.19
Ferrari, 1997	Switzerland	30	3	0.10
Good *et al.*, 2001	Switzerland	10	35	3.50
Present study	**Switzerland**	**41**	**3**	**0.07**

Regarding the latrines, their distribution and utilisation suggest that boundaries in the cultivated area are not well defined, as most of them are used only over a short period and the important ones are closer to the main setts than the others. This pattern is probably due to the low badger clan density (Cheeseman *et al.*, 1988; Lüps & Wandeler, 1993) or to the absence of neighbouring territories towards the centre of the valley (Kruuk, 1978). As a matter of fact, the spatial distribution of latrines observed in the Val-de-Ruz is different to what has been observed elsewhere (England: Roper *et al.*, 1986; Ireland: O'Corry-Crowe *et al.*, 1993). As far as we know, there are only three studies describing the same pattern of distribution: Graf *et al.* (1996) and Do Linh San (2002) in two Swiss rural areas and Cresswell & Harris (1988) in a British urban habitat. According to the latter, this distribution could be due to the heterogeneity and the unpredictability of food resources in the urban habitat and the authors argue that the same situation could be observed in rural areas with low badger densities. Our study confirms the low badger clan density in a cultivated area, but the cause seems not to lie in the food resource distribution (Fischer, 1997) but rather in the scarcity of potential den sites.

After Pigozzi (1989), the fact that the number of latrines used each month is positively correlated to the number of faeces present would mean that badgers defecate preferentially in the same latrines, the number of which depends on the amount of produced scats and thereafter on the quantity of ingested food. However, in this interpretation, this author does not consider the volume of the faeces and the digestibility of ingested items. Furthermore, several authors have shown that the maximal food consumption takes place in autumn to gain weight before winter (Skoog, 1970; Stocker & Lüps, 1984; Roper, 1994) whereas the number of scats placed in latrines and the

number of used latrines is maximal in spring, when territorial marking is most intensive. The positive correlation between these factors is rather linked to this intensity of territorial marking and the rest of the year, scats are less often deposited in latrines.

The role of territorial marking in the European badger is not yet unanimously recognised. After Kruuk (1978) the badger defends its food resources. On the other hand, Roper *et al.* (1986) and Roper & Lüps (1993) argue that the access to mating partners is the defended resource. In a similar way, Doncaster & Woodroffe (1993) and Roper (1993) consider that the defence of the breeding den is actually the proximate cause of territorial behaviour. Stewart *et al.* (1997) propose another explanation of the role of territorial marking which could be additional or an alternative to the "defence" role. They described a «passive range exclusion» hypothesis in which mutual avoidance would create range exclusion. The border latrines would act as information sites to signal resource depletion between 2 groups.

Our observations in the Val-de-Ruz are consistent with the hypothesis that the main sett represents a valuable resource which is surrounded by important marking stations, the more conspicuous latrines. The cultivated area acts as a reservoir with overabundant food supply (Fischer *et al.*, in prep.). Furthermore, the scarcity of suitable den sites does not allow the establishment of a dense population. Consequently, food resources do not need to be defended there like in high badger density areas.

So far, most studies were conducted in high density populations, with many clans, where the defended territory, marked with major latrines, is supposed to match with the home range (Macdonald, 1983). In our study area, where densities are very low, major latrines could also mark the defended territory and the minor ones are likely to be a sign of badger activity outside this defended area, thus indicating that the home range is not similar to the territory. Activity outside the territory limits is likely to be principally bound to foraging. Consequently, food resources are not likely to be the defended resource.

Thus, despite the apparent over-abundance of food resources due to modern cultural habits (Fischer *et al.*, in prep.) badger clan densities are low in the Val-de-Ruz. The absence of suitable den sites in such areas is likely to be the limiting factor (Da Silva *et al.*, 1993; Doncaster & Woodroffe, 1993; Reason *et al.*, 1993; Roper, 1993).

The ecology of the badger is probably quite different between low and high density areas. Unfortunately, these areas with small populations have been mostly disregarded up to now. However, these situations were badgers reach their ecological limits are more likely to give answers to many of the unexplained behavioural traits of this species.

ACKNOWLEDGEMENTS

We wish to thank N. Ferrari for his advice during the field work, and H. Kruuk and M. Do Linh San for useful comments on a first draft of the manuscript.

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